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Document Title **CAL Flight Module (FM 106 and FM 107) Thermal-Vacuum Test Report**		

Gamma-ray Large Area Space Telescope (GLAST)

Large Area Telescope (LAT)

Calorimeter Flight Module (FM 106 and FM 107) Thermal-Vacuum Test Report

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CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes
01	12 January 2005	Initial Release

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1 INTRODUCTION

1.1 PURPOSE

This report presents the results of the acceptance thermal-vacuum (TVAC) test performed on two GLAST Calorimeter (CAL) Modules, designated as Flight Module 106 (FM 106) and Flight Module 107 (FM 107). This test was performed from November 30, 2004 through December 10, 2004 in accordance with LAT-PS-04455-03, *CAL Flight Module Thermal-Vacuum Test Procedure*, and work orders, WOA-01646, *Preparation of CAL Tower Module for TVAC Testing (FM 106)*, WOA-01647, *Preparation of CAL Tower Module for TVAC Testing (FM 107)*, WOA-01648, *CAL Module TVAC Test (FM 106)*, WOA-01649, *CAL Module TVAC Test (FM 107)*.

1.2 OBJECTIVE

The two primary objectives of this test are:

- To verify the functional, electrical and thermal performance of FM 106 and FM 107 over the acceptance temperature range of –20 °C to +35 °C.
- To characterize the functional performance of FM 106 and FM 107 at the cold operating temperature of –5 °C.

Throughout the test, functional and performance testing of the AFEE and Tower Electronics Module (TEM) electronics is performed to verify that:

- Proper communication between TEM and CAL Module exists
- All registers of the CAL Module function properly
- Pedestal amplitude and noise in all four energy ranges remain stable
- Optical performance of each Crystal Detector Element (CDE) remains stable.

1.3 VERIFICATION

This test satisfies the requirements for verification of the GLAST CAL Module as specified in the LAT Calorimeter Verification & Environmental Test Plan, LAT-SS-01345.

2 APPLICABLE SPECIFICATIONS

Documents required to perform this test include the as-run version of LAT-PS-04455, CAL Flight Module Thermal-Vacuum Test Procedure, and the associated work orders (WOA). The applicable documents cited in this standard are listed in this section only for reference.

2.1 GOVERNMENT SPECIFICATIONS

The following specifications, standards and handbooks form a part of this document to extent specified herein.

Number	Title
GEVS-SE	General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components

2.2 NON-GOVERNMENT SPECIFICATIONS

Number	Title
LAT-MD-00408	LAT Instrument Performance Verification Plan
LAT-MD-01370	CAL Comprehensive and Limited Performance Test Definition
LAT-MD-04187	CAL Electronic and Muon Calibration Definition
LAT-PS-01513	CAL Functional Test and Calibration Procedure
LAT-PS-04237	CAL Module Handling Procedure
LAT-PS-04455	CAL Flight Module Thermal-Vacuum Test Procedure
LAT-SS-00788	LAT Environmental Specification
LAT-SS-01345	LAT CAL Verification & Environmental Test Plan
LAT-SS-00971	CAL Program Quality Assurance Plan
ANSI/ESD S20.20-1999	Standard for the Development of an ESD Control Program
N/A	Instrumentation Manuals

2.3 DRAWINGS

Number	Title
LAT-DS-00916	Calorimeter Module, GLAST
LAT-DS-01643	TEM-TPS Assembly
LAT-DS-04536	Calorimeter Tower Module

2.4 ORDER OF PREFERENCE

In the event of a conflict between this document and the technical guidelines cited in other documents referenced herein, the technical guidelines of this document take precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3 TEST DECRIPTION

3.1 TEST OBJECTIVE

The objective of this test was to verify the performance of FM 106 and FM 107 over the acceptance and operational temperature ranges.

3.2 TEST METHODOLOGY

TVAC testing was conducted in a TVAC chamber held at 1.0×10^{-5} torr. Both CAL Modules were simultaneously subjected to four thermal-vacuum cycles at the temperature extremes of –20 °C to +35 °C. At the conclusion of the fourth cycle, both CAL Modules were held –5 °C, to characterize their performance at their cold operational temperature.

The test fixture, as shown in Figure 3-1, consisted of cold plates, which provide the temperature control for temperature ramp and dwell during the test. The temperature of the cold plates were managed with cooling tubes supplying liquid nitrogen (LN_2) and resistive heaters. Each test article and fixture was thermally isolated from the walls of the thermal-vacuum chamber by MLI blankets.

Functional tests that occurred in the thermal-vacuum environment are outlined below:

- Survival turn-on sequence – conducted at each hot and cold survival plateau of the first test cycle.
- Comprehensive Performance Tests (CPT) - conducted at each temperature plateau of all test cycles.
- Limited Performance Tests (LPT) - conducted during thermal transitions, where system failures or intermittent problems are most likely to occur.
- Muon Collection and additional science testing – conducted during thermal transitions and at each temperature plateau of all test cycles.

The thermal-vacuum test also fulfilled the bakeout function requirement since the structure was above 40 °C during a majority of the transitions. A contamination plate was installed within the vacuum chamber during the test to collect volatiles released during the TVAC test thereby preventing contamination of the CAL from condensed released volatiles.

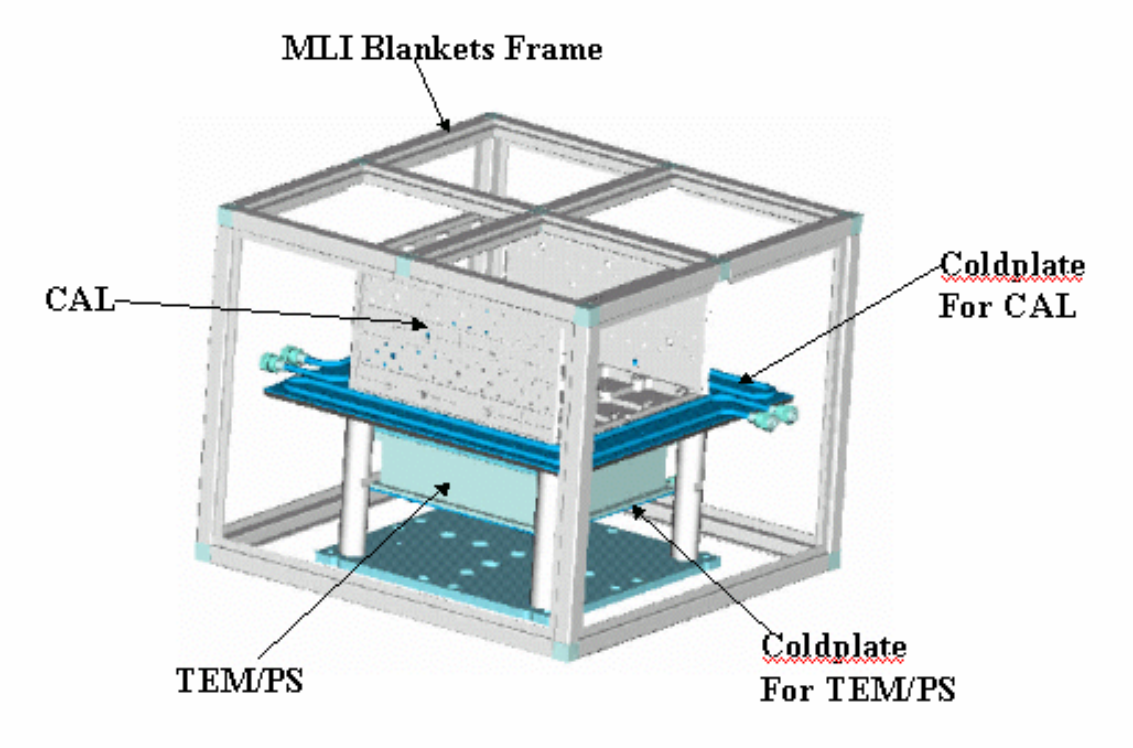


Figure 3-1: Test Fixture Set-up for Thermal-Vacuum Test

(MLI Thermal Blankets Removed For Clarity)

3.3 TEST ARTICLE DESCRIPTION

The test articles were the GLAST CAL Tower Module, FM 106 and FM 107, as documented in the as-built configuration list (ABCL) shown in Table 5-1. Each CAL Tower Module (LAT-DS-04536) consisted of the CAL Module (LAT-DS-00916) with the Tower Electronics Module/Power Supply (TEM/TPS) Assembly (LAT-DS-01643) attached to the CAL Module base plate by means of four rigid stand-offs.

There are no deviations from the flight configuration with the exception that the TEM/TPS Assembly is version EM2, rather than its actual flight version. The GLAST CAL Tower Module in flight configuration is shown in Figure 3-2.

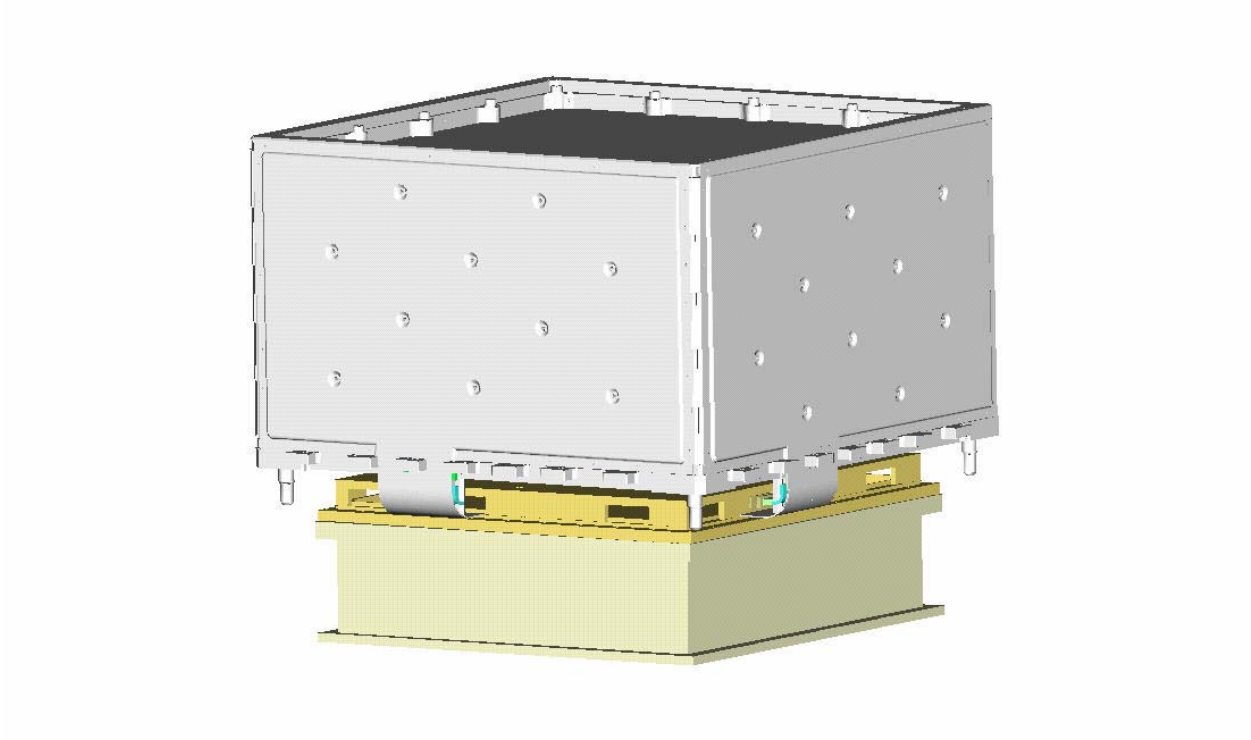


Figure 3-2: CAL in Flight Configuration with TEM/TPS

4 TEST RESPONSIBILITIES

4.1 TEST PERSONNEL

Key test personnel are defined below. The responsible points of contact (POC) for this test procedure are listed in Table 4-1.

Table 4-1: Test Personnel

Role	Name	Telephone Number
Project Representative	Eric Grove	202-767-3112
Test Director	Paul Dizon	202-404-7193
Test Conductor, Primary	Mike Van Herpe	202-767-3944
Test Conductor, Electrical Subsystem	Byron Leas	202-404-1464
Test Conductor, Science Subsystem	Eric Grove	202-767-3112
Instrumentation/Data Support	Mike Van Herpe	202-767-3944
Thermal Analysis Support	Peck Sohn	301-902-4098
Electrical Subsystem Engineering Support	James Ampe	202-404-1464
Quality Assurance Support	Nick Virmani	202-767-3455
	Lamont Franklin	202-404-1332

4.1.1 Project Representative

The Project Representative represents the GLAST project and will have the responsibility to ensure that no violations of project procedures or CAL handling procedures take place.

4.1.2 Test Director

The Test Director (TD) will have primary responsibility for directing test activities, maintaining the log, documenting the test schedules, coordination of resources, and preparation and close-out of all Problem Reports (PRs). The TD will also have the primary responsibility for all data collection and evaluation during the test for the final test report. The TD will be responsible for coordinating the inputs from the Test Conductors and Quality Assurance representatives, developing the as-run test file, and for executing the as-run test approval sheet. This includes assuring that all PRs have been properly prepared and correctly executed.

4.1.3 Test Conductor

The Test Conductor(s) (TC) will be responsible for a specific activity being conducted. The Primary Test Conductor will also be responsible for the entire laboratory, installation and check-out of instrumentation, data acquisition, and data reduction. The other TC(s) will be responsible for executing their specified test procedures. The TC(s) is also responsible for the preparation, operation of test equipment, and the scheduling of daily activities mentioned in the test procedure.

4.1.4 Support Personnel

Support Personnel are responsible for specific activities supporting installation of instrumentation, managing data, and providing real-time data analysis support.

5 GENERAL TEST PROGRAM REQUIREMENTS

5.1 TEST SETUP

5.1.1 Test Location

The thermal-vacuum test was conducted in the Thermal-Vacuum Test Laboratory (in the oil-free cryo-pumped TVAC test chamber, known as *Big Blue*) of the Payload Check-Out Facility, Building A-59, at the Naval Research Laboratory, Washington, D.C.

5.1.2 Test Article Configuration

The As-Built Configuration List (ABCL) of the CAL Tower Module (LAT-DS-04536) in its test configuration is shown in Table 5-1.

Table 5-1: As-Built Configuration List – TVAC Test

Assembly / Component	Part Number	Status
Calorimeter Tower Module, s/n FM 106	LAT-DS-04536	Flight/GSE
Calorimeter Module, s/n FM 106	LAT-DS-00916	Flight
TEM/TPS Assembly, s/n FM 07	LAT-DS-01643	GSE
M6 Screws, Socket-Head Cap (QTY 4)	NA0069-060024	GSE
M6 Washers, Flat (QTY 4)	A370-903-32	GSE
Calorimeter Tower Module, s/n FM 107	LAT-DS-04536	Flight/GSE
Calorimeter Module, s/n FM 107	LAT-DS-00916	Flight
TEM/TPS Assembly, s/n FM 10	LAT-DS-01643	GSE
M6 Screws, Socket-Head Cap (QTY 4)	NA0069-060024	GSE
M6 Washers, Flat (QTY 4)	A370-903-32	GSE

5.1.3 Test Equipment

The following test equipment and systems were used in the execution of this test:

- Test Chamber: NRL Big Blue TVAC Chamber (cryo-pump)
- Test Article: FM 106 CAL Module with EM2 TEM/TPS
  FM 107 CAL Module with EM2 TEM/TPS
- Test Article Support: CAL TVAC Test Fixture with Cold Plates/MLI Blankets
  CAL Lift Fixture and Accessories
- Thermocouples: 36 (total)
- Temperature Control System: CDACS (NRL Computer Data Acquisition System) System (PC Computer and HP 34970A Data Acquisition/Switch Units running the CDACS software)
  - Four LN_2 Solenoid Valves
  - Eight 50 W (CAL Cold Plate) Heaters
  - Eight 25 W (TPS Cold Plate) Heaters
- Data Acquisition and Control CDACS System (PC Computer and HP 34970A Data Acquisition/Switch Units running the CDACS software)
- Electrical Test Equipment Two Calorimeter Test Stand Data Acquisition Unit

Both CAL Tower Modules were mounted in the upright position onto their TVAC test fixtures, as shown in Figure 5-1. Three cold plates provided the TVAC test environment for each module. Two liquid nitrogen-cooled cold plates (CAL Cold Plates) were attached to each CAL Tower Module using the flight interface (tabs of the CAL Module base plate) as attachment points. Another liquid nitrogen-cooled cold plate (TPS Cold Plate) was attached to the –Z surface of each TPS. Four 50 W and four 25 W heaters were installed on the CAL Cold Plates and TPS Cold Plate of each CAL Tower Module, respectively. The CDACS (Computer Data Acquisition System) system, which consisted of a dedicated PC computer workstation and HP 34970A Data Acquisition/Switch Units controlled by the CDACS software, controlled the flow of liquid nitrogen into the coolant tubes and power to the heaters in order to control temperature ramp and maintain the test temperature, as required.

Each TVAC test fixture was isolated from the test chamber by G-10 spacers. The entire test article and fixture were thermally isolated from the walls of the thermal-vacuum chamber by MLI blankets. These blankets were mounted to an exterior box frame, which was also isolated from the test chamber by G-10 spacers. The MLI blankets surrounded the entire TVAC test fixture.

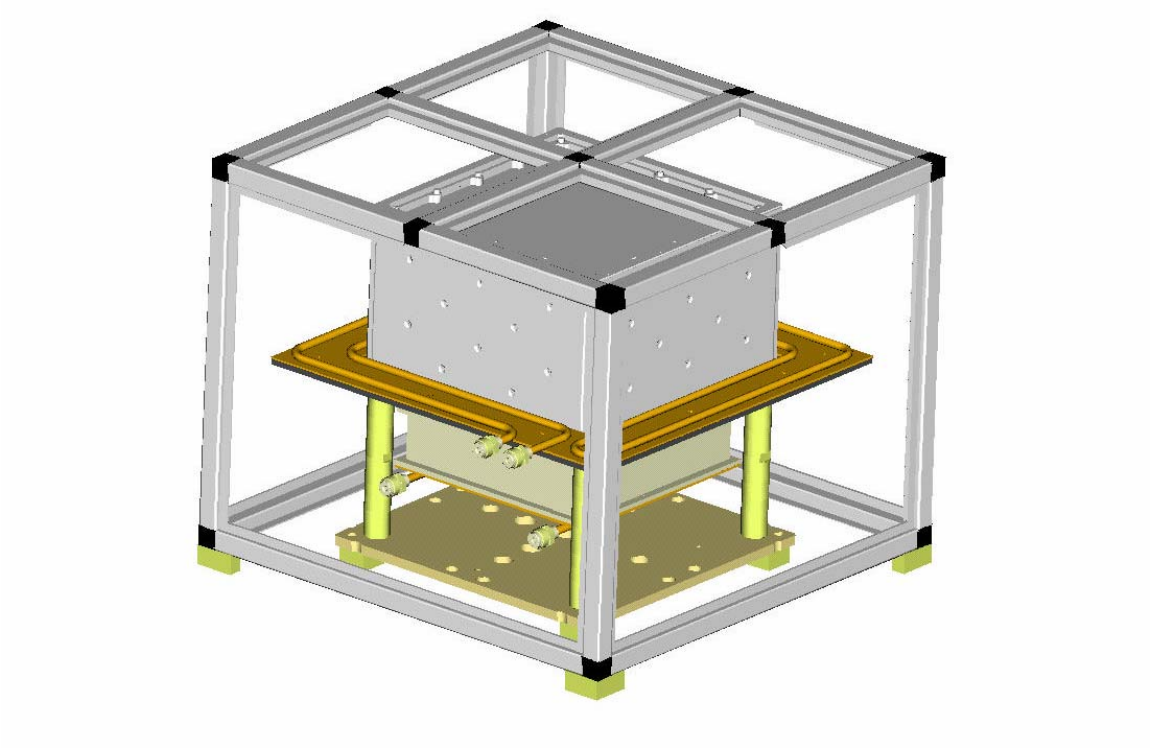


Figure 5-1: Test Fixture with CAL Module
(MLI Thermal Blankets Removed for Clarity)

5.2 INSTRUMENTATION AND DATA ACQUISITION

5.2.1 Instrumentation

Test article instrumentation consisted of external thermocouples as well as thermistors integral to the AFEE cards (one per card) and TEM-TPS (four total).

FM 106 and FM 107 were each instrumented with four thermocouples. 14 additional thermocouples were placed onto the test fixture (CAL cold plate and TPS cold plate for each CAL Tower Module as well as the contamination plate). These additional thermocouple channels were monitored during the test in order to control the temperature environment. The thermocouple locations are listed in Table 5-2 and illustrated in Figure 5.2 and Figure 5.3.

5.2.2 Calibration

Prior to testing, the thermocouples were calibrated by comparison against a standard temperature (0 °C).

5.2.3 Data Acquisition

Three data acquisition systems were used for this test:

- One CDACS System.
- Two Calorimeter Test Stand/Data Acquisition Units.

The CDACS system, which consisted of a dedicated PC computer workstation and data acquisition/switch units controlled by the CDACS software, was used to collect temperature data from thermocouples on the Flight CAL Tower Module, the test fixture (CAL cold plate and TPS cold plate), and the TVAC chamber. Temperature data was acquired at a sampling rate of 1 sample every 5 minutes. All acquired data was stored on the computer in a comma delimited (.csv) file format.

Each Calorimeter Test Stand/Data Acquisition Unit consisted of a dedicated PC running the LATTE software, a power supply, and a custom VME data acquisition system was used to collect science and housekeeping telemetry from the TEM of the Flight CAL Module. Temperature data from the AFEE card thermistors was imbedded in the housekeeping data stream.

Table 5-2: Thermocouple Locations for the Acceptance TVAC Test

TC ID	Location	TC ID	Location
1	Top of Structure – Center	10	CAL Cold Plate Inlet 1
2	Top of Structure – Center	11	CAL Cold Plate Inlet 2
3	+X Base Plate – Bottom Corner	12	CAL Cold Plate Inlet 2
4	- X Base Plate – Bottom Corner	13	CAL Cold Plate Y-Connection
5	CAL Cold Plate Assembly, +X	14	TPS Cold Plate Inlet 1
6	CAL Cold Plate Assembly, - X	15	TPS Cold Plate Inlet 1
7	CAL Cold Plate Assembly, +Y	16	TPS Cold Plate
8	CAL Cold Plate Assembly, - Y	17	TPS Cold Plate
9	CAL Cold Plate Inlet 1	18	Contamination Plate

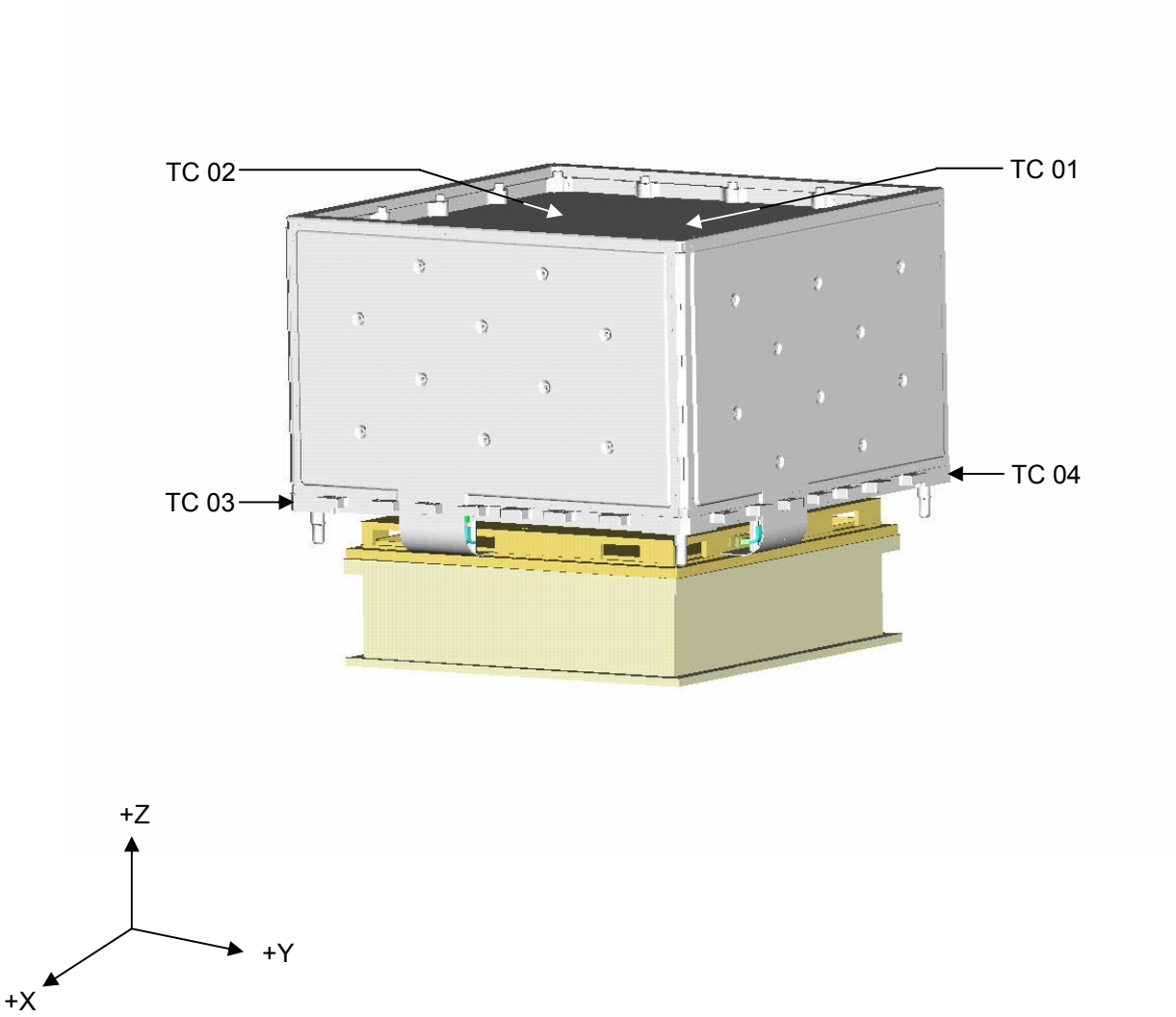
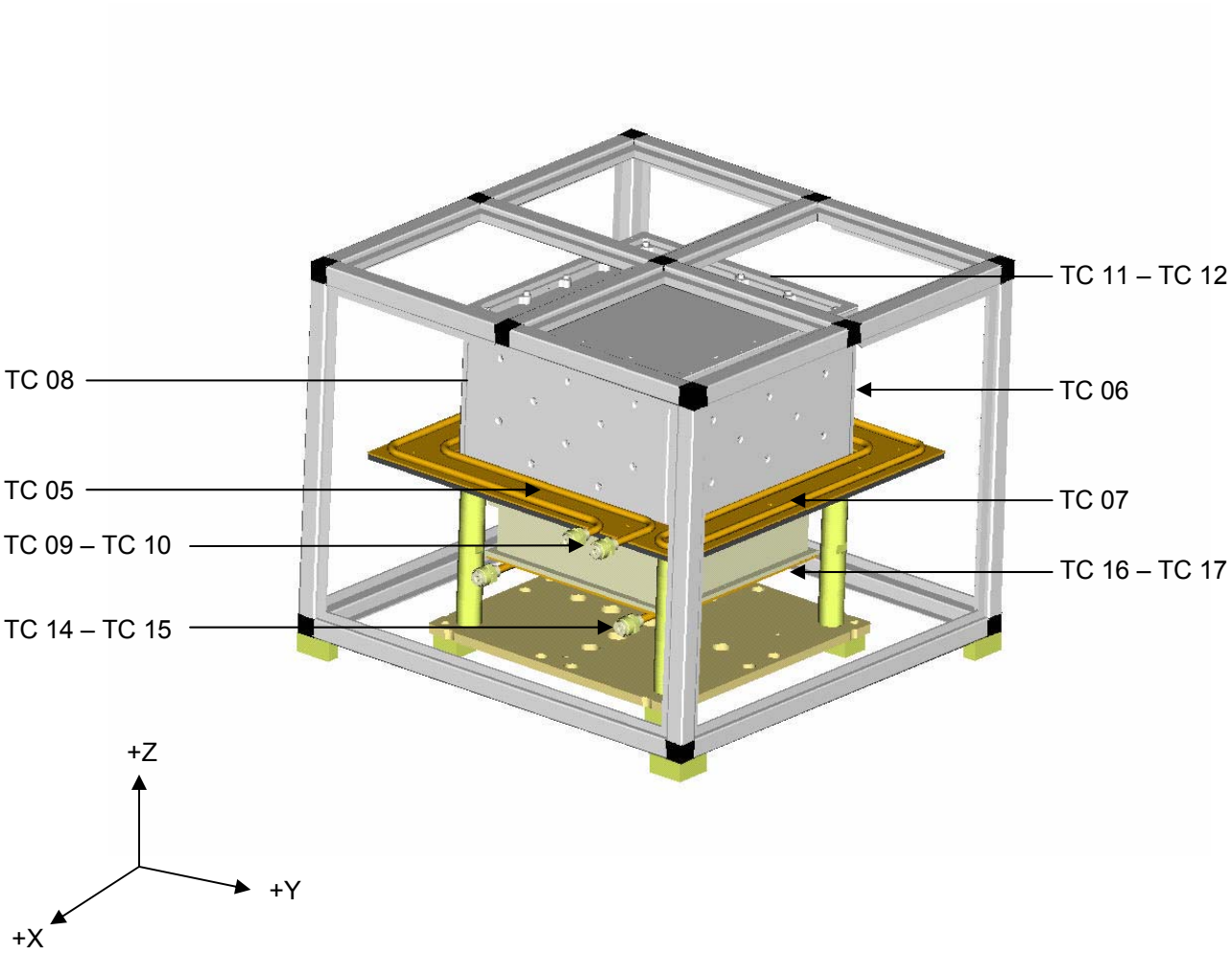


Figure 5-2: Thermocouple Locations for CAL Tower Module



NOTE: TVAC Chamber Thermocouples Not Part of Test Article

TC 13 (LN_2 Junction Fitting)
TC 18 (Contamination Plate)

Figure 5-3: Thermocouple Locations for the Test Fixture
(MLI Thermal Blankets Removed for Clarity)

5.3 VACUUM CHAMBER TEST CONDITIONS AND TOLERANCES

Prior to installation of the test articles, the thermal-vacuum chamber outgassing performance was verified by the TVAC facility staff as acceptable for flight testing (based on the previous tests performance), and then the chamber was cleaned by isopropyl alcohol wipe-down of all accessible surfaces of the chamber.

5.3.1 Environmental Conditions and Tolerances

The required test temperature levels for the CAL Tower Module are –20 °C to +35 °C. The cold operational temperature level for the CAL Tower Module is -5 °C.

Hot soak and cold soak temperatures of the AFEE and CDEs was maintained within $\pm$ 3 °C. The TVAC test fixture and cold plate temperatures are capable of maintaining any temperature within $\pm$ 5 °C and a ramp rate no greater than 30 °C per hour. CDEs cannot exceed a ramp rate of 10 °C per hour throughout the test. Vacuum was maintained at 1.0×10^{-5} torr or better.

5.3.2 Outgassing

All hardware used in the TVAC chamber meets the NASA outgassing requirements.

5.3.3 Temperature Limits

Throughout the test, the CAL Module and AFEE temperatures are limited +60 °C and –40 °C during drive hot and drive cold temperature profiles, respectively.

Per SLAC direction due to the functional performance problem at the cold temperature, the temperature of the EM2 TEM/TPS was maintained at +25 °C $\pm$10 °C.

When the test temperatures exceed their allowable limits, the CDACS software notifies the Test Conductor with an audible and visual alarm followed by a warning message displayed on the terminal screen.

6 TEST PROCEDURE OVERVIEW

The thermal-vacuum test for FM 106 and FM 107 was divided into two phases: 1) thermal-vacuum cycling, 2) operational temperature function test.

The thermal-vacuum test, which included electrical functional testing as well as muon performance testing, followed the temperature profile and test timeline as described in Section 6.1 and Section 6.5 of LAT-PS-04455-03, *CAL Flight Module Thermal-Vacuum Test Procedure*.

Electrical functional testing and muon collection was performed in accordance with LAT-PS-01513, *CAL Functional Test and Calibration Procedure.*

The test sequence for FM 106 and FM 107 is summarized as follows:

1. Installation of CAL Tower Module into the Test Fixture
2. Installation of the Test Article into the TVAC Test Chamber
    - Limited Performance Test
3. Thermal-Vacuum Cycle 1
    - Temperature Transitions
        - Limited Performance Test
        - Muon Collection (Ground Configuration)
    - AFEE Card Temperature Soak
        - AFEE Card Power-Down/Up Test
        - Comprehensive Performance Test
    - 4 Hour CAL Module Temperature Soak
        - Bake-Out
        - Comprehensive Performance Test
        - Muon Collection (Ground Configuration) and additional science testing
4. Thermal-Vacuum Cycle 2
    - Temperature Transitions
        - Limited Performance Test
        - Muon Collection (Ground Configuration)
    - 4 Hour CAL Module Temperature Soak
        - Comprehensive Performance Test
        - Muon Collection (Ground Configuration)
5. Thermal-Vacuum Cycle 3
    - Temperature Transitions
        - Limited Performance Test
        - Muon Collection (Flight Configuration)
    - 4 Hour CAL Module Temperature Soak
        - Comprehensive Performance Test
        - Muon Collection (Flight Configuration)

6. Thermal-Vacuum Cycle 4
    - Temperature Transitions
        - Limited Performance Test
        - Muon Collection (Ground Configuration)
    - 4 Hour CAL Module Temperature Soak
        - Comprehensive Performance Test
        - Muon Collection (Ground Configuration)
7. Ramp to Ambient - Operational Temperature
    - Temperature Transitions
        - Limited Performance Test
        - Muon Collection (Ground Configuration)
    - 4 Hour CAL Module Temperature Soak –5 °C
        - Comprehensive Performance Test
        - Muon Collection (Ground Configuration) and additional science testing
8. Removal of the Test Article from the TVAC Test Chamber

6.1 TEMPERATURE PROFILE

The thermal cycling of FM 106 and FM 107 was conducted at the acceptance temperature range, –20 °C through +35 °C. A performance characterization test at the operational temperatures of –5 °C was also conducted after the last cycle.

The thermal-vacuum test requires 4 cycles. The test profile is shown in Figure 6-1. Cycle 1 also fulfilled the bake-out function of the structure.

During the cold or hot soak period of each TVAC cycle, the CAL and TPS Cold Plates were set according to the temperatures in Table 6-1. To expedite the hot and cold transition from plateau to plateau, the CAL cold plate was ramped up or down by the rate of 30 °C per hour and set to maximum +60 °C for hot transition and –40 °C for cold transition before settling to the protoflight temperature ranges at the final stage of transition.

There are no thermocouples installed on the CDEs inside of CAL module. Based on analysis, the temperatures on the top of CAL Module and CDEs merge closely together as their temperatures reach their final stage of transition to the hot and cold plateaus. Therefore, the thermocouples attached to the top of the CAL Module are monitored as control points for tests.

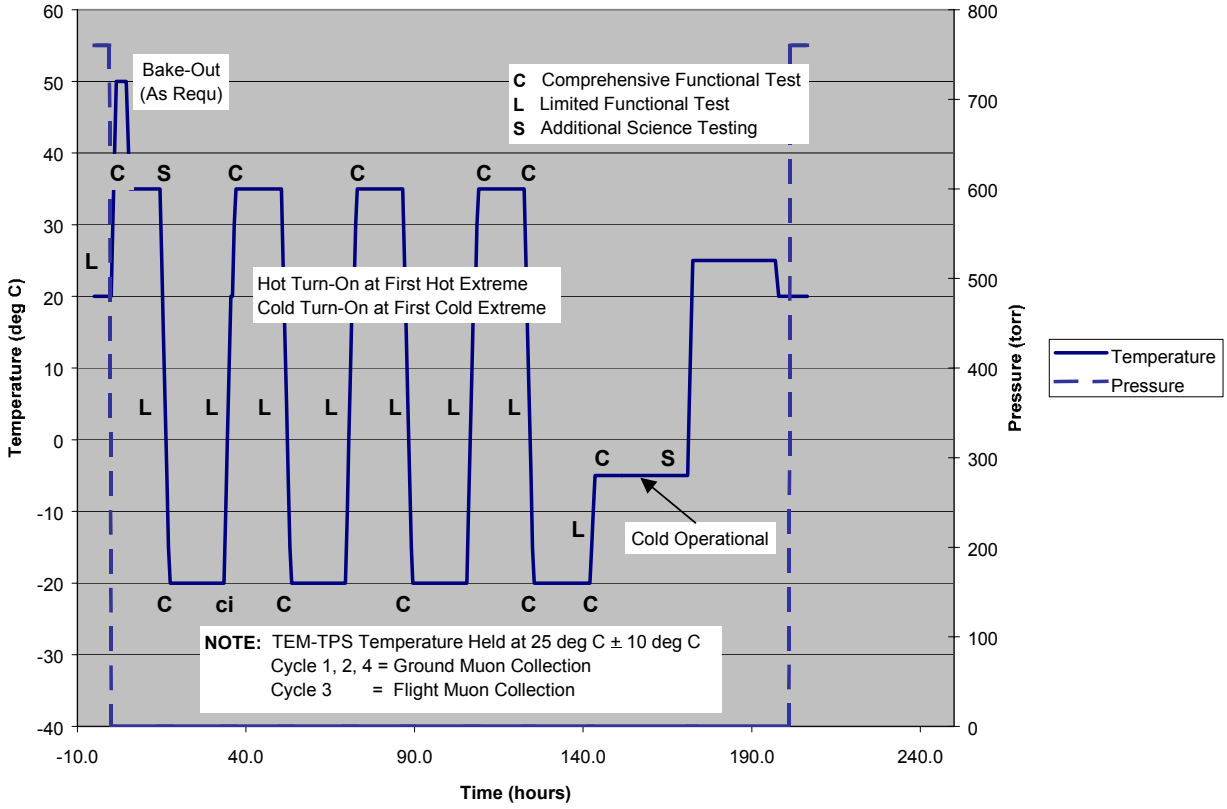


Figure 6-1: CAL Module Temperature Profile for Thermal-Vacuum Testing

Table 6-1: CAL Module Temperature Levels for Thermal-Vacuum Testing

TEST COMPONENT	ACCEPTANCE LIMITS	
	COLD (deg C)	HOT (deg C)
CAL Module	-20	+35
TEM-TPS	+15	+35
CAL Cold Plate Assembly	-23	+35
TPS Cold Plate Assembly	+20	+20

6.2 FUNCTIONAL AND MUON TESTING DEFINITIONS

Throughout the TVAC Test, both limited and comprehensive electrical functional testing as well as muon performance testing was conducted on FM 106 and FM 107 in accordance with LAT-PS-01513, *CAL Functional Test and Calibration Procedure*.

6.2.1 Survival Turn-On Sequence

Survival turn-on sequence was performed at the hot survival plateau and cold survival plateau of the first thermal test cycle.

6.2.2 Limited Performance Testing of AFEE and TEM

Limited Performance Testing (LPT) verified selected elements of the electrical function of the AFEE and TEM electronics. This test was conducted during thermal transitions, where system failures or intermittent problems are most likely to occur.

6.2.3 Comprehensive Testing of AFEE and TEM

Comprehensive Performance Testing (CPT) verified the full electrical function of the AFEE and TEM electronics. This test was conducted at each hot and cold plateau of the thermal test cycles.

6.2.4 Science Performance Testing

Science Performance Testing provides additional opportunity for the scientist to run additional performance tests to verify and characterize the performance of the CAL module. These tests were conducted at each temperature plateau of Cycle 1 and the operational test temperature, as directed by the Science Subsystem Test Conductor.

6.2.5 Cosmic Muon Test

Cosmic ray muons provide patterns of energy deposition in the CAL that are analogous to the flight science data. The muon test provides a limited end-to-end functional test of science data acquisition and science performance. The LPT and CPT contain brief muon data accumulations. Longer, dedicated muon accumulations were performed at the conclusion of the CPT when temperature of the CAL Module was at its plateau. This test was also conducted throughout the test flow.

7 TEST SEQUENCE AND RESULTS

FM 106 and FM 107 were tested in accordance with LAT-PS-04455-03, *CAL Flight Module Thermal-Vacuum Test Procedure*, and work orders, WOA-01547, WOA-01552, WOA-01605 and WOA-01606. Temperature profile of all cycles are shown in Figure 7-1. Results and anomalies of each cycle are summarized in the following sections.

7.1 TVAC CYCLE 1

TVAC Cycle 1 started on December 2, 2004. Temperature ramp and dwell were nominal. AFEE hot/cold start, LPT, CPT, additional science tests, as directed by the Science Test Director, (CalibGen.py and muTrg.py), and muon collection (ground configuration) occurred throughout the cycle as outlined in the test schedule found in Section 6.5.1 of LAT-PS-04455-03.

While FM 106 and FM 107 were in its hot soak temperature, the CPT failed when trigger sweep timed out before all events were drained due to the VME improperly initializing. Reboot of the VME properly reinitialized the system. Work around to this EGSE design problem is addressed in *CAL FM Procedure for Execution of Functional Tests and Calibration*, LAT-PS-01513-04. This anomaly was documented in PRB-0542.

Furthermore, during the hot and cold temperature dwells of TVAC Cycle 1, the calibGen.py script failed when performed on both FM 106 and FM 107 due to calf_trg_p03 failure. Further investigation showed that there was a LEX8 fitting problem since the analysis algorithm in the calf_trg_p03, which was originally designed for the LEX1 gain, did not function properly in all cases for the LEX8 gain. Inspection of data showed that performance is within specification, but not properly handled by analysis. This is a known problem, which has been resolved in the CAL software release v2. This anomaly is documented in PRB-0543, which also documents the same failure observed during Cold Operational Temperature Cycle for both FM 106 and FM 107.

While FM 106 was in its hot soak temperature, the CPT failed in calf_shp_p01 since the software incorrectly applied the test requirements during analysis. This anomaly is documented in PRB-0545 and has already been addressed and resolved in CAL software release v2.

Also while in its hot soak temperature, the calibGen.py script failed when performed on FM 107. It appears that the log object got corrupted while running the script. This was an intermittent problem that was not reproducible during the test. The problem fixed itself upon reboot. This anomaly is documented in PRB-0546.

7.2 TVAC CYCLE 2

TVAC Cycle 2 started on December 4, 2004. Temperature ramp and dwell were nominal, with the exception of the EM2 TEM-TPS. During the ramp to hot temperature, the EM2 TEM-TPS (s/n FM 10) of FM 107 exceeded its specified temperature range (+15 deg C to +35 deg C) due to operator error. Although the maximum temperature briefly reached 40 deg C, the TEM-TPS still functioned properly throughout the remainder of the TVAC test. The temperature of the TEM-TPS exceeded its specification due to a closed LN_2 hand-valve supplying its cold plate. This anomaly is documented in PRB-0547.

LPT, CPT, and muon collection (ground configuration) occurred throughout the cycle according to the test schedule outlined in Section 6.5.2 of LAT-PS-04455-03.

7.3 TVAC CYCLE 3

TVAC Cycle 3 started on December 6, 2004. Temperature ramp and dwell were nominal. LPT, CPT, and muon collection (flight configuration) occurred throughout the cycle according to the test schedule outlined in Section 6.5.3 of LAT-PS-04455-03.

During the ramp to hot temperature of FM 107, the AFEE temperature values displayed in the Run Control window differed from those displayed in the Environmental Quantities window by 4 deg C. Values displayed in the Run Control window are temperatures measured at the beginning and end of unit tests and may not reflect the temperatures displayed in the Environmental Quantities window, which are real-time temperatures. This anomaly is documented in PRB-0548.

While the FM 107 was at its hot soak temperature, calf_adc_p02 output plots indicated that Channel X-3:2 (located at board -X, Row 3, Column 2) was visibly noisy since the GCFE started to become noisy, itself. This channel has failed and the LEX8 and LEX1 ranges have been noted as noisy in the Exception List. As a result, the CAL scripts have been modified to check the Exceptions List prior to evaluating Pass/Fail. This anomaly is documented in PRB-0549.

During the ramp to cold temperature of FM 107, the system stopped during muon collection. The trigger rate decreased to zero and the CPU rate decreased to approximately 45%. There appeared to be a communication error between the VME and the test computer. Reboot of the VME reestablished communication. Work around to this EGSE design problem is addressed in *CAL FM Procedure for Execution of Functional Tests and Calibration*, LAT-PS-01513-04. This anomaly is documented in PRB-0550. Similar problems also occurred during TVAC Cycle 4.

7.4 TVAC CYCLE 4

TVAC Cycle 4 started on December 7, 2004. Temperature ramp and dwell were nominal. LPT, CPT, and muon collection (ground configuration) occurred throughout the cycle according to the test schedule outlined in Section 6.5.4 of LAT-PS-04455-03.

While FM 106 was at both its hot soak and cold soak temperature, the CPT failed when margin testing was applied (clock frequency at 22 MHz). Possible cause was the test cable, which limited the test below 22 MHz. CPT was repeated for both modules without margin testing and passed. This anomaly is documented in PRB-0544.

During the ramp to cold temperature and cold soak of FM 107, the system stopped during muon collection. The trigger rate and the CPU rate decreased. There appeared to be a communication error between the VME and the test computer. Reboot of the VME reestablished communication. Work around to this EGSE design problem is addressed in *CAL FM Procedure for Execution of Functional Tests and Calibration*, LAT-PS-01513-04. This anomaly was also observed in TVAC Cycle 3 and is documented in PRB-0550.

7.5 COLD OPERATIONAL TEMPERATURE DWELL

Testing at the cold operational temperature started on December 9, 2004. Temperature ramp and dwell were nominal. CPT, additional science tests, as directed by the Science Test Director, (CalibGen.py and muTrg.py), and muon collection (ground configuration) occurred at this temperature according to the test schedule outlined in Section 6.5.5 of LAT-PS-04455-03.

During the temperature dwell, the calibGen.py script failed when performed on both FM 106 and FM 107 due to Calf_trg_p03 failure. This failure is the same failure that occurred during Thermal Cycle 1, as documented in PRB-0543. Inspection of data showed that performance is within specification, but not properly handled by analysis. This is a known problem, which has also been resolved in the CAL software release v2.

TVAC testing concluded on December 10, 2004.

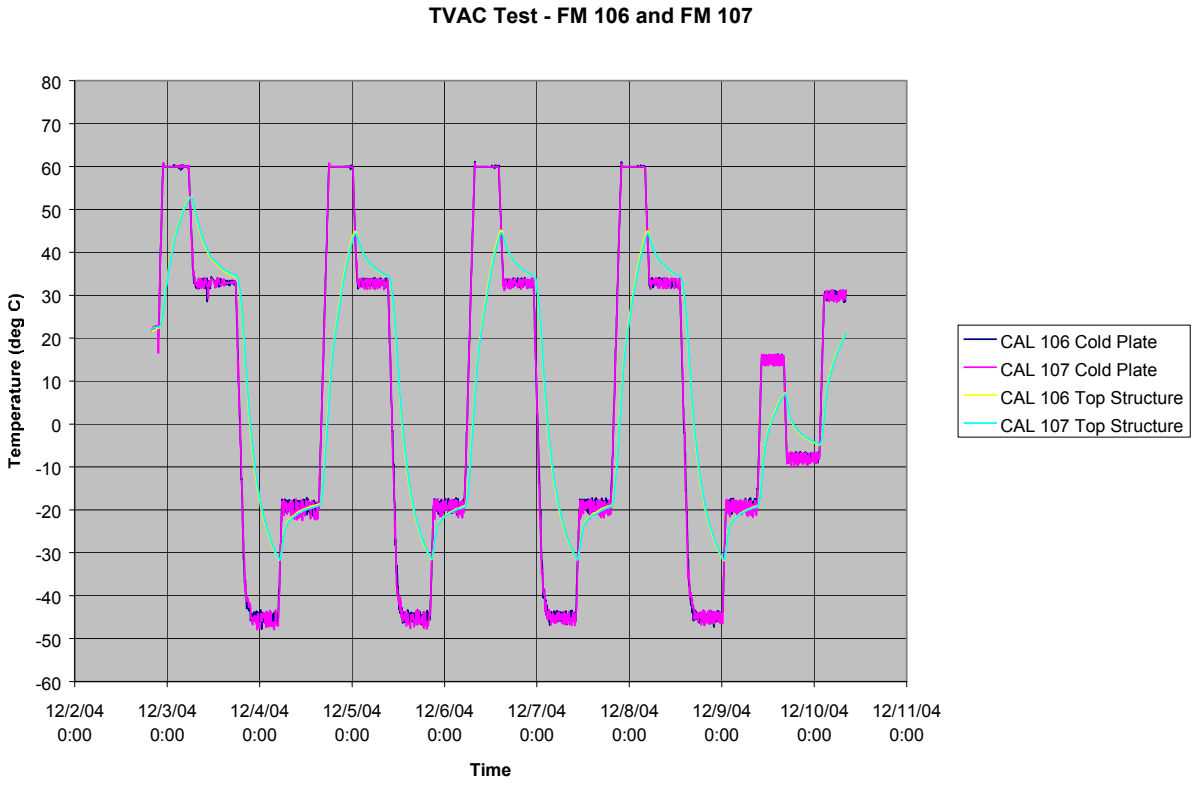


Figure 7-1: TVAC Test Cycle Temperature Profile

8 CONCLUSIONS

The FM 106 and FM 107 CAL Tower Modules passed this series of TVAC testing since the following criteria, as specified in LAT-PS-04455-03, *CAL Flight Module Thermal-Vacuum Test Procedure*, were met:

- The environmental conditions and tolerances were applied in accordance to those described in Section 5.3.1 and Section 5.3.2.
- Acquisition of thermal data was recorded in accordance with Section 5.2.
- Functional test data for the AFEE and TEM electronics was collected in accordance with, LAT-PS-01513, *CAL Functional Test and Calibration Procedure*.
- Cosmic muon test data was collected in accordance with, LAT-PS-01513, *CAL Functional Test and Calibration Procedure*.
- FM 106 and FM 107 incurred no detrimental damage or change in the electrical functional pass/fail status (CPT, LPT, and cosmic muon collection).